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ABSTRACT

Full-term neonates from 37 pairs of same-sex twins, either small or appropriate for gestational age (SGA/AGA), were observed during the first sleep cycle after feeding to determine if behavioral indices of central nervous system (CNS) functioning were related to risk for the SGA infants. No differences were observed between groups for time spent in active or quiet sleep or length of the first sleep cycle. Both large and small limb movements were observed less frequently in SGA infants than AGA infants, and startles and spontaneous smiles were observed more frequently during active sleep in SGA infants than AGA infants. Consideration of behavioral state cycles as an index of CNS organization initially suggests that SGA neonates are not at higher risk than their AGA twins. Consideration of spontaneous behaviors during active sleep may be useful for early identification of individual SGA infants at risk. (Author/RH)

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Sleep State Indices of Risk for Small-for-Gestional-Age Neonates

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ABSTRACT

Fullterm neonates from 37 pairs of appropriate-for-gestational-age/small-for-gestational-age (AGA/SGA) same-sex twins were observed during the first sleep cycle after feeding to determine if behavioral indices of CNS functioning were related to risk for the SGA infants. No differences were observed between groups for time spent in active or quiet sleep, or length of the first sleep cycle. Both large and small limb movements were observed less frequently in SGA infants than AGA infants; and startles and spontaneous smiles were observed more frequently during active sleep in SGA infants than AGA infants. Consideration of the relation between these variables with maturation of the CNS, and comparison of the frequency of their occurrence with that for other risk groups, has implications for the assignment of risk for SGA infants.

INTRODUCTION

When compared with appropriate-for-gestational-age (AGA) children, small-for-gestational-age (SGA) children have been described as likely to have a higher incidence of neurological, psychomotor, and behavioral abnormalities, poor scores on developmental tests, and learning difficulties in school (e.g., Allen, 1984; Parkinson et al, 1981; Tenovuo et al, 1988, for reviews). However, SGA infants are not necessarily developmentally delayed; for example, failure to find differences between AGA and SGA children has been reported for mental development, language development, motor development, and hearing and vision (Allen, 1984; Babson & Kangas, 1969; Paine & Pasquali, 1982; Parmelee & Schulte, 1970; Tenovuo et al, 1988). Thus, prediction of risk for developmental problems for SGA children as a group is difficult, and it is not clear at birth or in early infancy which SGA infants will be most at risk for problems (e.g., Parkinson et al, 1981).

One way of evaluating the developmental integrity of the infant for possible early identification of infants at risk for developmental problems is by observation of neonatal sleep behaviors and behavioral state cycling, as the organization of states has been related to central nervous system (CNS) functioning (Fukumoto et al, 1981; Korner et al, 1988; Prechtl et al, 1973; Watt & Strongman, 1985). The behavioral indices observed during neonatal sleep have been found to be predictive of later developmental problems (Thoman et al, 1981), and have been suggested to be good indicators for detecting normal and abnormal CNS development (Booth et al, 1980; Fukumoto et al, 1981).

METHOD

Subjects. The sample consisted of 37 pairs of same-sex fullterm twins in which one twin of the pair was appropriate-for-gestational-age (AGA) and the other twin was small-for-gestational-age (SGA). Observation of twins allowed for the control of gross prenatal and obstetrical variables that may differentially influence neonatal behavior. Size for gestational age was determined by using the norms from Lubchenco, Hansman, and Boyd (1966) that define SGA infants as those in the lower 10th percentile of weight for gestational age. Size for gestational age was not determined until after the assessment was completed. Information on perinatal variables, including weights, is presented in Table 1.

Procedure. The infants were tested when they were medically stable, just before discharge from the hospital (Table 1). Each neonate was assessed for 10 minutes during the first active sleep period following a nursery scheduled feeding. Time-sampling recordings, consisting of alternating 15-second observation and recording periods, were made of the occurrence of the following spontaneous behaviors: the number of limbs moved (0 to 4) and the vigor of limb movement (slight, moderate, or large); body movements consisting of startles and stretches; head movements; movements of hands to face; mouth movements consisting of smiles, grimaces, sucks, and other general mouth movements. In addition, the entire first sleep cycle was observed to determine the length of the total cycle, and the length of the first active sleep period and the first quiet sleep period.

RESULTS

Initial Differences Between Groups: Examination of the variables that may have indicated initial differences between the SGA and AGA infants indicated that there were no differences between the groups for 1- and 5-minute Apgar scores (although there was a trend for AGA infants to have higher 1-minute Apgar scores than SGA infants), chronological age at test, or latency to sleep after feeding (Table 1).

AGA-SGA Differences in Sleep Variables: To determine if there were differences between the AGA and SGA infants in the sleep cycle or ratings on the behaviors observed in active sleep, *t* tests were computed between the groups for these variables. There were no differences between the groups for the time spent in first active sleep, time spent in first quiet sleep, or the length of the first sleep cycle (Table 1).

Differences between the groups on specific behaviors during active sleep then were examined for 20 twin pairs in which both infants of the pair remained in active sleep for a sufficient time to be observed for 10 minutes. Significant differences were observed between the AGA and SGA infants, as follows (Table 2). AGA infants had more vigorous movements than SGA infants; AGA infants had more right hand-to-mouth movements than SGA infants; and SGA infants had more spontaneous smiles than AGA infants. In addition, certain trends were observed: SGA infants tended to startle more frequently than AGA infants; AGA infants tended to have more small limb movements than SGA infants; and AGA infants tended to have more left hand-to-face movements than SGA infants (Table 2).

Stepwise Discriminant Analysis: To determine if the above sleep variables that were found to occur with different frequencies for the AGA and SGA infants might be used to differentiate between these two groups, a stepwise discriminant

analysis was computed with the six variables. The summary of this analysis is presented in Table 3. The variables right hand-to-mouth, smile, large limb movement, startle, and left hand-to-face significantly discriminated between the two groups. Right hand-to-mouth was removed at step 5 as it no longer was necessary to add to the discrimination between the groups once the next three variables had been entered.

The discriminant analysis also predicts group membership on the basis of the composite discriminant scores. The jackknifed classification indicated that 90% (18 of 20) of the AGA infants were correctly placed in the AGA group, and 75% (15 of 20) of the SGA infants were correctly placed in the SGA group. Examination of the canonical variables indicated that, for those infants who were misclassified, the misclassification margin was relatively small. Thus, the discriminant analysis demonstrated that the composite of these four sleep variables was sensitive to differences between AGA and SGA fullterm infants.

CONCLUSIONS

These findings have implications for the assignment of risk for SGA infants. Consideration of behavioral state cycles as an index of CNS organization initially suggests that SGA neonates are not at higher risk than their AGA co-twins. However, consideration of spontaneous behaviors during active sleep may be useful for early identification of individual SGA infants at risk.

Some of the specific behaviors that differentiated between these AGA and SGA infants previously have been evaluated as markers of risk for neonates. For example, the motor movements have been indicated to be related to the maturational process of the CNS and have been suggested to be useful to detect abnormal CNS development (Fukumoto et al, 1981). These motor movements were observed less frequently in SGA infants than in AGA infants. In contrast, startles, which typically occur in quiet sleep rather than in active sleep in healthy neonates, were observed more frequently in SGA infants than in AGA infants. And, neonatal smiles, which have been related to spontaneous discharge of subcortical origin and previously have been observed more frequently in high-risk preterm infants than fullterm infants (Emde & Koenig, 1969; Sroufe & Waters, 1976), occurred more frequently in the SGA group than in the AGA group.

The results of the stepwise discriminant analysis indicated that a composite score can be created from behaviors observed in active sleep to assign risk for individual infants. Finding 90% correct classification for AGA infants suggests that a specific pattern of behavior exists for infants who are not at risk. Finding 75% correct classification for SGA infants may help to remove infants from the high-risk group when their behavior patterns are similar to those of the low-risk group.

Table 1

Means and Ranges of Perinatal and Sleep Cycle Variables for AGA and SGA Infants (N = 37 pairs)

Variable	AGA		SGA		t for Means
	Mean	Range	Mean	Range	
Birth weight (grams)	2856	2381-3657	2263	1673-2651	9.18, $p < .0001$
Test weight (grams)	2687	2211-3459	2230	1871-2523	7.89, $p < .0001$
Test chronological age (days)	3.8	1-7	4.9	1-21	
1-minute Apgar	7.9	4-9	7.3	4-9	1.79, $p < .08$
5-minute Apgar	8.8	8-10	8.7	7-10	
Latency to sleep after feeding (minutes)	3.9	0-16	8.9	0-99	
Time in first active sleep (minutes)	25.4	4-68	20.5	0-66	
Time in first quiet sleep (minutes)	15.5	0-30	16.7	0-32	
Length of first sleep cycle (minutes)	43.8	16-101	39.7	0-68	

Table 2

Means and Ranges of Sleep Variables for AGA and SGA Infants (N = 20 pairs)

Variable	AGA		SGA		t for Means
	Mean	Range	Mean	Range	
Large limb movement	.45	0-2	.10	0-1	2.08, $p < .05$
Right hand-to-mouth	.65	0-3	.15	0-1	2.23, $p < .04$
Smile	.60	0-2	1.45	0-5	-2.08, $p < .05$
Startle	.45	0-2	.80	0-2	-1.70, $p < .10$
Small limb movement	2.4	0-10	1.4	0-4	1.77, $p < .09$
Left hand-to-face	2.6	1-6	1.8	0-6	1.72, $p < .10$
Stretch	2.1	0-5	1.6	0-5	
Head movement	6.4	1-14	5.0	1-11	
Right hand-to-face	3.4	0-8	3.0	0-10	
Left hand-to-mouth	.05	0-1	.00	0	
Grimace	.75	0-3	.80	0-4	
Suck	.35	0-4	.10	0-1	
General mouth movement	12.6	5-17	11.0	3-19	

Table 3

Stepwise Discriminant Analysis of Sleep Variables for AGA and SGA Infants

Step No.	Variable Entered (E) or Removed (R)	*F* Value to Enter or Remove	No. of Variables Included	Approximate *F* - Statistic	Degrees of Freedom	
1	Right hand-to-mouth (E)	4.97	1	4.97*	1	38
2	Smile (E)	4.70	2	5.08*	2	37
3	Large limb movement (E)	4.83	3	5.34**	3	36
4	Startle (E)	11.40	4	8.02***	4	35
5	Right hand-to-mouth (R)	3.99	3	8.64***	3	36
6	Left hand-to-face (E)	6.18	4	8.96***	4	35

* $p < .05$; ** $p < .01$; *** $p < .001$

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